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PATENT

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: : CHARLES R. SPINNER, III ET AL
Serial No. : 09/871,463
Filed : May 31, 2001
For : BARRIER FILM DEPOSITION OVER METAL FOR
REDUCTION IN METAL DISHING AFTER CMP
Group No. : 2815
Examiner : M.E. Warren

MAIL STOP APPEAL BRIEF - PATENTS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

APPELLANTS' BRIEF ON APPEAL

This Brief is submitted in triplicate on behalf of Appellants for the application identified above. A check is enclosed for the \$320.00 fee for filing a Brief on Appeal. Please charge any additional necessary fees to Deposit Account No. 50-0208.

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REAL PARTY IN INTEREST

The real party in interest for this appeal is the assignee of the application, STMICRO-ELECTRONICS, INC. (f/k/a SGS-THOMSON MICROELECTRONICS, INC.).

RELATED APPEALS AND INTERFERENCES

There are no appeals or interferences related to the present application which are currently pending.

STATUS OF CLAIMS

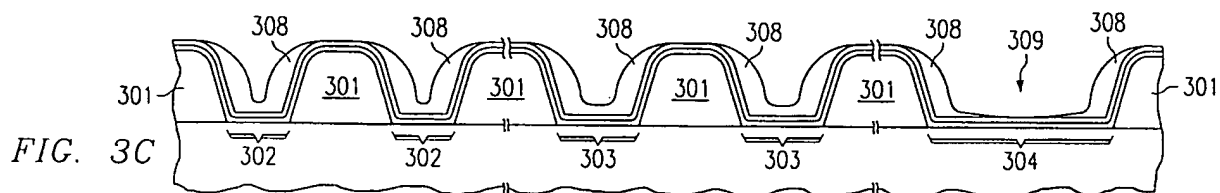
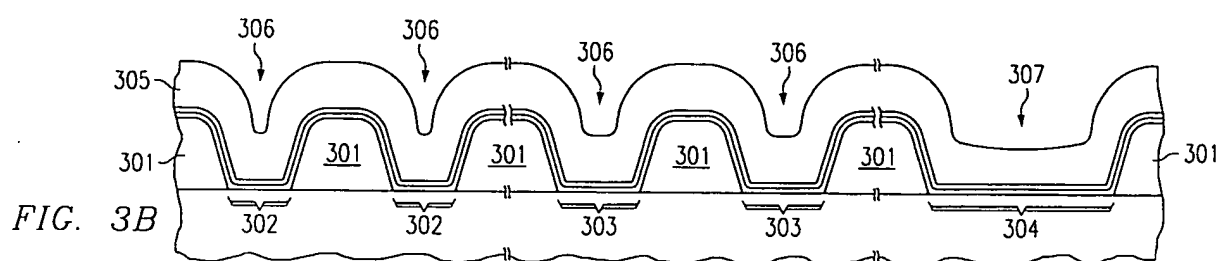
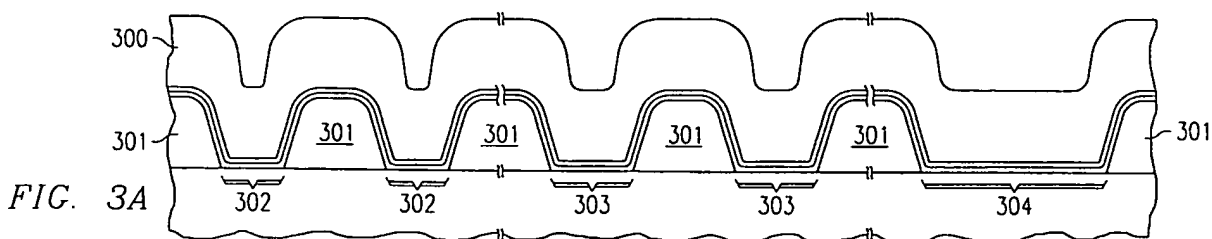
Claims 1–20 are pending in the present application. Claims 1–7 were restricted from claims 8–20 pursuant to 35 U.S.C. § 101 and withdrawn from further consideration. Claims 8–9, 11 and 16–18 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,175,154 to *Gillespie*. Claims 8–14 and 16–18 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,103,625 to *Marcyk et al.* Claims 15 and 20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of U.S. Patent No. 6,346,741 to *Van Buskirk et al.* Claim 19 was rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of U.S. Patent No. 6,103,625 to *Joshi et al.* The restriction of pending claims 1–7 and the rejection of pending claims 8–20 is appealed.

STATUS OF AMENDMENTS

No amendments to the claims were submitted following the final Office Action mailed November 19, 2002.

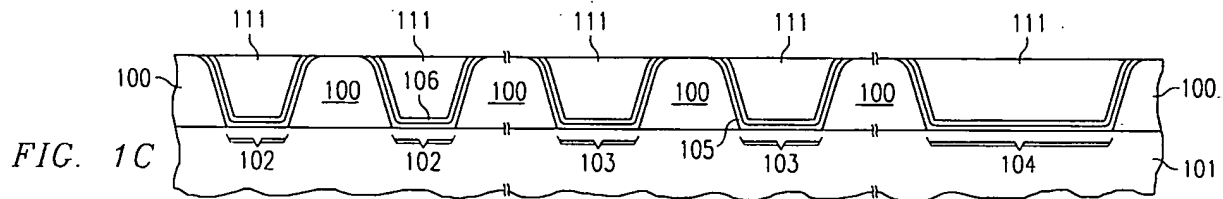
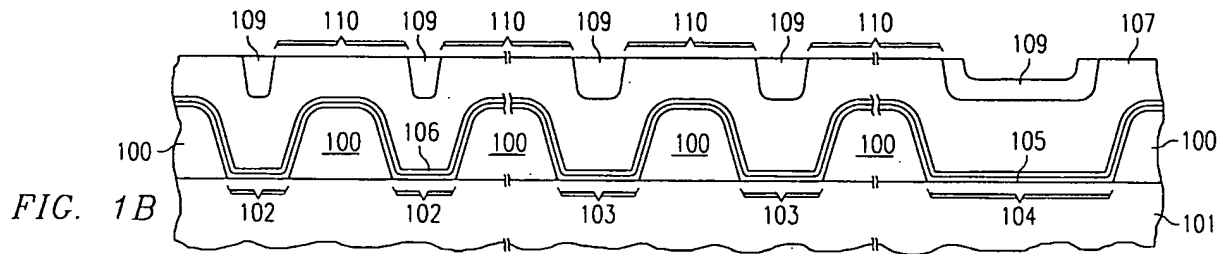
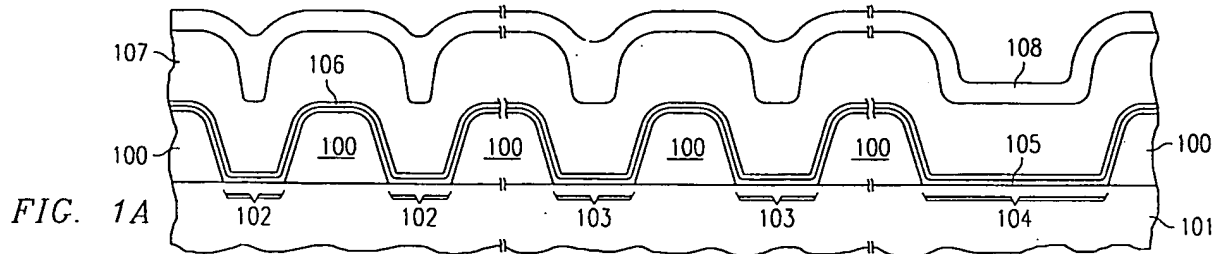
SUMMARY OF THE INVENTION

The present invention relates to chemical mechanical polishing (CMP). For tungsten metal layers within an integrated circuit, chemical mechanical polishing utilizes an abrasive slurry containing chemical oxidizing the tungsten metal, with the tungsten metal oxide then being removed by a combination of abrasion and chemical action. Specification, page 2, lines 19–23. While this produces planar upper surfaces, the typical chemical mechanical polishing process for tungsten is primarily chemical in nature, and therefore results in uniform removal of tungsten, largely independent of topography. Specification, page 3, lines 1–18. A problem of thinning or “dishing” of tungsten layers results, particularly for tungsten regions having a large area, such as a metal-oxide-semiconductor capacitor 304, within a layer including smaller area regions such as contacts 302. A conformal tungsten layer 300 of uniform thickness formed over a dielectric 301 having openings 302–304 therein and patterned or “etched back” by chemical mechanical polishing will thus be thinner over large area openings 304 than over small area openings 302 after chemical mechanical polishing:



Specification, Figures 3A-3C, page 3, line 20 through page 5, line 14.

The present invention reduces dishing during chemical mechanical polishing of conformal tungsten layers. A conformal tungsten layer 107 is formed over a patterned dielectric layer 100 having openings 102–104 therein exposing an underlying substrate layer 101:

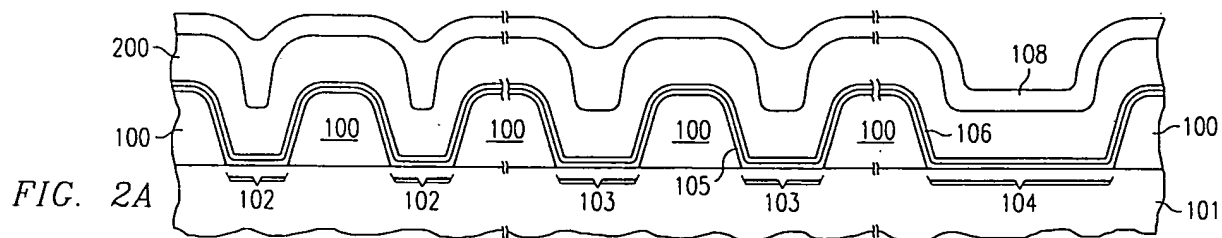


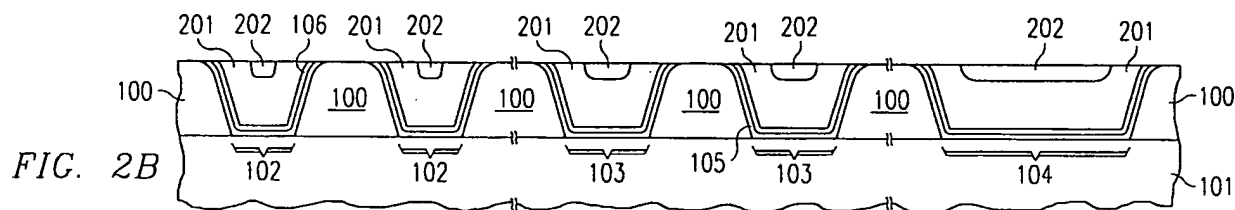
Specification, Figures 1A–1C, page 10, line 19 through page 11, line 3. Openings 102–104 may be of varying widths or areas, such as small or narrow contact openings 102, medium width interconnect grooves 103, and wide capacitive electrodes 104. Specification, page 11, lines 4–16.

A protective barrier layer 108 is formed over the conformal tungsten layer 107, formed from a material such a titanium nitride (TiN) for which chemical mechanical polishing is primarily

mechanical rather than primarily chemical, such that higher topological regions are removed or “etched back” faster than lower topological regions. Specification, page 11, line 17 through page 12, line 22. During chemical mechanical polishing, the barrier layer 108 reduces dishing by preventing chemical attack of underlying tungsten metal until completely removed in a given area. Specification, page 13, lines 3–14.

In one embodiment of the present invention, where the tungsten layer 107 is thicker than the underlying dielectric layer 100 (i.e., the tungsten layer 107 is thicker than the depth of the unfilled portions of openings 102–104 within dielectric layer 100), the protective barrier layer 108 will be completely removed during chemical mechanical polishing as shown in Figure 1C. Specification, page 13, line 15 through page 14, line 2. In another embodiment, where the tungsten layer 200 is not as thick as the underlying dielectric layer 100, the protective barrier layer 108 is not completely removed during chemical mechanical polishing, and portions 202 of the protective barrier material remain over central portions of each opening 102–104:





Specification, Figures 2A–2B, page 14, line 3 through page 15, line 6. The reduction in dishing achieved by the present invention improves process margins and yield.

ISSUES ON APPEAL

Claims 1–20 are pending in the present application. Claims 1–7 were restricted from claims 8–20 pursuant to 35 U.S.C. § 101 and withdrawn from further consideration. Claims 8–9, 11 and 16–18 were rejected under 35 U.S.C. § 102(e) as being anticipated by *Gillespie*. Claims 8–14 and 16–18 were rejected under 35 U.S.C. § 102(e) as being anticipated by *Marcyk et al.* Claims 15 and 20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Van Buskirk et al.* Claim 19 was rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Joshi et al.* The issues on appeal are:

1. Whether claims 1–7 were properly restricted from claims 8–20 pursuant to 35 U.S.C. § 101;
2. Whether claims 8–9, 11 and 16–18 were properly rejected under 35 U.S.C. § 102(e) as being anticipated by *Gillespie*;

3. Whether claims 8–14 and 16–18 were properly rejected under 35 U.S.C. § 102(e) as being anticipated by *Marcyk et al*; and

4. Whether claims 15 and 20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Van Buskirk et al*.

GROUPING OF CLAIMS

Claims 1–20 are pending in the present application. Claims 1–7 were restricted from claims 8–20 pursuant to 35 U.S.C. § 101 and withdrawn from further consideration. Claims 8–9, 11 and 16–18 were rejected under 35 U.S.C. § 102(e) as being anticipated by *Gillespie*. Claims 8–14 and 16–18 were rejected under 35 U.S.C. § 102(e) as being anticipated by *Marcyk et al*. Claims 15 and 20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Van Buskirk et al*. Claim 19 was rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Joshi et al*. For purposes of this appeal, the pending claims will be grouped together as follows:

Group A – claims 1–7;

Group B – claims 8–20;

Group C – claim 12;

Group D – claims 15 and 20;

Group E – claim 17;

Group F – claim 19.

Groups A–F stand or fall independently. Patentability of the claims within each group is argued separately below.

ARGUMENT

Group A (Claims 1–7)

Claims 1–7 of Group A were restricted from claims 8–20 pursuant to 35 U.S.C. § 101 and withdrawn from consideration. These claims are properly grouped together and considered separately from the claims of Groups B–F since the claims of Group A are subject to a different grounds of rejection than the claims of Groups B–F.

The Restriction Requirement asserts that the method claims (1–7) and the structure claims (8–20) are distinct because the structure of claims 8 and 16 may be manufactured by a materially different process than that recited in claim 1. Specifically, the Restriction Requirement asserts that the product and process are distinct because “etching, instead of chemical mechanical polishing, could be used to remove portions of the protective barrier layer.”

Restriction is only proper where the claims are independent or distinct. MPEP § 806. In passing on questions of restriction, the claimed subject matter must be compared in order to determine distinctness and independence. MPEP § 806.01. In the present application, pending independent claim 8 does not require removal of any portion of the protective barrier layer. Instead, claim 8 reads on a structure prior to removal of portions of the protective barrier layer by, preferably, chemical mechanical polishing. In addition, it is not apparent that the structure recited in pending

independent claim 16 could be formed by etching rather than chemical mechanical polishing. Claim 16 recites a portion of a protective barrier layer over a central region of the tungsten and within the opening. Isotropic etching would uniformly remove a conformal protective barrier layer, while anisotropic etching for partial removal would remove the vertically thinner portions (e.g., at the center of an opening) leaving sidewalls alongside vertical or sloped surfaces. Neither type of etching would result in the structure recited in claim 16. Similarly, the Advisory Action mailed March 10, 2003 asserts that chemical mechanical polishing may be employed to form a trench for trench isolation. None of the pending claims recite trench isolation.

In addition, a process of making and the product made are distinct inventions only if: (A) the process as claimed is not an obvious process of making the product and can be used to make other and different products; and (B) the product as claimed can be made by another and materially different process. The Restriction Requirement provides no basis for concluding that simple etching is materially different--i.e., patentably distinct--over chemical mechanical polishing.

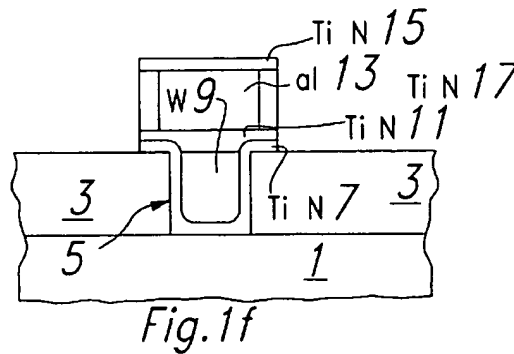
Group B (Claims 8–20)

Claims 8–9, 11 and 16–18 of Group B were rejected under 35 U.S.C. § 102(e) as being anticipated by *Gillespie*. Claims 8–14 and 16–18 of Group B were rejected under 35 U.S.C. § 102(e) as being anticipated by *Marcyk et al.* Claims 15 and 20 of Group B were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Van Buskirk et al.* Claim 19 of Group B was rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Joshi*

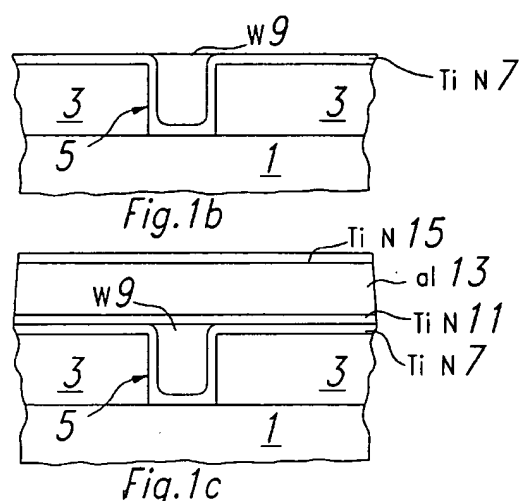
et al. These claims are properly grouped together and considered separately from the claims of Groups A and C-F since the claims are subject to a different grounds of rejection than the claims of Group A and since a favorable decision with respect to the claims of Group B may obviate the need for consideration of the claims of Groups C-F.

Independent claims 8 and 16 each recite that the protective barrier layer overlies the tungsten and is disposed within the opening through the dielectric. That is, independent claims 8 and 16 are directed to the second embodiment described above and depicted in Figures 2A-2B, in which the tungsten layer 200 is thinner than the unfilled portions of the openings 102-104 within dielectric layer 100 and portions 202 of protective barrier material 108 therefore remain over the tungsten regions 201 and within the openings 102-104 after chemical mechanical polishing. Such a feature is not found in the cited reference(s), taken alone or in combination.

The structure of Figure 1F of *Gillespie*, cited in the Office Action as anticipating the claims of Group B, depicts tungsten 9 within an opening in dielectric 3 and overlying titanium nitride region 11 above the opening in dielectric layer 3 rather than within the opening in dielectric 3:



Gillespie, Figure 1f. In fact, Figure 1f within *Gillespie* is erroneous since the structure depicted is formed from a structure in which the tungsten 9 more than fills the opening 5 within the dielectric layer 3, and titanium nitride 11 is spaced apart from the top of the opening by the thickness of titanium nitride layer 7:



Gillespie, Figures 1b and 1c, column 2, lines 40–60. *Gillespie* is silent as to forming titanium within the opening 5 in dielectric layer 3.

Both independent claims of Group B recite that the protective barrier layer is formed within the opening(s). Independent claim 8 of Group B recites “a protective barrier layer over the tungsten layer and within the openings,” and thus reads on the structure depicted in Figure 2A. Independent claim 16 recites “a portion of a protective barrier layer over a central region of the tungsten and within the opening,” and thus reads on the structure depicted in Figure 2B. In these embodiments of the invention, the tungsten layer 200 is formed with a thickness insufficient to fill the openings

102–104 and the overlying protective barrier layer 108 fills any remainder of openings 102–104 not filled by tungsten layer 200. Specification, Figures 2A–2B, page 14, 9–14. The protective barrier layer is thus disposed within the openings 102–104, as well as over the tungsten layer 200.

The Office Action relies on an interpretation of “within the opening” as requiring only that the titanium nitride lie within a boundary defined by sidewalls of the opening, without necessarily extending into the opening (i.e., below the upper surface of the dielectric). Such an interpretation is contrary to the ordinary meaning of the term “within” and to the specification, and is therefore without basis in the record and arbitrary and capricious. The interpretation adopted in the Office Action would be appropriate to the recitation “above the opening,” but is contrary to the plain meaning of “within the opening.”

Group C (Claim 12)

Claim 12 of Group C was rejected under 35 U.S.C. § 102(e) as being anticipated by *Marcyk et al.* This claim is properly considered separately from the claims of Groups A–B and D–F since the claim is subject to a different grounds of rejection than the claims of Group A and since the claim of Group B contains a limitation distinguishing the claimed invention over the cited references that is not recited in the claims of Groups B and D–F.

Claim 12 of Group C recites that the protective barrier layer--which is within the opening as recited in independent claim 8--overlies portions of the tungsten layer within the openings but not portions of the tungsten layer over the dielectric layer--that is, the claim recited the structure after

partial removal or etch back of the protective barrier layer and tungsten metal layer, similar to the structure of Figure 1B except that the protective barrier material is within the opening, not merely over the opening. Such a feature is not found within the cited reference. None of the references, taken alone or in combination, depicts a protective barrier layer over a tungsten layer and within an opening, but only over tungsten within the opening and not also over tungsten overlying the dielectric including the opening.

Group D (Claims 15 and 20)

Claims 15 and 20 of Group D were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Van Buskirk et al*. These claims are properly considered separately from the claims of Groups A–C and E–F since the claims are subject to a different grounds of rejection than the claims of Group A and since the claims of Group D contain a common limitation distinguishing the claimed invention over the cited references that is not recited in the claims of Groups B–C and E–F.

Claims 15 and 20 each recite that at least one opening within the dielectric layer is sized to form a capacitive electrode from tungsten within the opening. Such a feature is not suggested by the cited references, taken alone or in combination. *Van Buskirk et al*, cited in the Office Action as providing motivation for modifying the teachings of *Marcyk et al* to include such a feature, employs a protective barrier layer under the interconnect for etch stop point detection, and also relates to a trench capacitor rather than a capacitive electrode for an MOS capacitor. Moreover, the mere

suitability of tungsten metal for use as a capacitor electrode does not provide a motivation for use of the specific structure shown in *Marcyk et al* to form a capacitive electrode, particular since formation of a trench capacitor as taught by *Van Buskirk et al* is not attended by the dishing problems associated with large area MOS capacitor electrodes.

Group E (Claim 17)

Claim 17 of Group E was rejected under 35 U.S.C. § 102(e) as being anticipated by *Gillespie*. Claim 17 of Group E was also rejected under 35 U.S.C. § 102(e) as being anticipated by *Marcyk et al*. This claim is properly considered separately from the claims of Groups A–D and F since the claim is subject to a different grounds of rejection than the claims of Group A and since the claim of Group E contains a limitation distinguishing the claimed invention over the cited references that is not recited in the claims of Groups B–D and F.

Claim 17 of Group E recites that a upper surface of the tungsten is exposed around the portion of the protective barrier layer within the opening over a central region of the tungsten within the opening. Such a feature is not found in the cited references. None of the cited references, taken alone or in combination, depicts or describes a protective barrier layer that is both within an opening and exposes portions of an underlying tungsten layer around the protective barrier layer.

Group F (Claim 19)

Claim 19 of Group F was rejected under 35 U.S.C. § 103(a) as being unpatentable over *Marcyk et al* in view of *Joshi et al*. This claim is properly considered separately from the claims of

Groups A–E since the claim is subject to a different grounds of rejection than the claims of Group A and since the claim of Group F contains a limitation distinguishing the claimed invention over the cited references that is not recited in the claims of Groups B–E.

Claim 19 of Group F recites that the tungsten and the protective barrier layer form an upper surface substantially planar with an upper surface of the dielectric layer. Such a feature is not found in the cited references. *Marcyk et al* depicts protective barrier region 208b, 308b above the upper surface of dielectric layer 202, 302. *Joshi et al* describes a titanium nitride layer below a tungsten metal region 17, not over the tungsten metal as recited in the claims. Nothing in either references suggests that the respective teachings may be successfully combined and modified to achieve the claimed invention, with a protective barrier layer and underlying tungsten metal forming an upper surface substantially planar with the dielectric.



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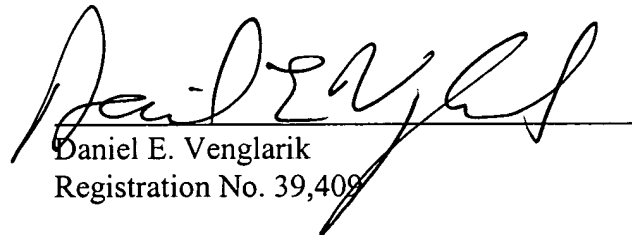
CONCLUSION

The restriction of the claims of Group A has no basis in the claims and is unsupported by any evidence of record. Therefore, the restriction under 35 U.S.C. § 101 is improper. None of the cited references, taken alone or in combination, depict or describe all features of the invention claimed in Groups B-F. Therefore, the rejections under 35 U.S.C. §§ 102 and 103 are improper. Applicant respectfully requests that the Board of Appeals reverse the decision of the Examiner below restricting the claims of Group A and rejecting all remaining pending claims in the application.

Respectfully submitted,

DAVIS MUNCK, P.C.

Date: 5-27-03


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**APPENDIX TO APPELLANT'S BRIEF ON APPEAL
PENDING CLAIMS ON APPEAL**

- 1 1. A method of forming a conductive structure within an integrated circuit comprising:
 - 2 forming a conformal tungsten layer over a dielectric layer and within openings within the
 - 3 dielectric layer;
 - 4 forming a protective barrier layer over the tungsten layer, wherein the protective barrier layer
 - 5 comprises a material for which removal by chemical mechanical polishing is primarily mechanical;
 - 6 and
 - 7 removing at least portions of the protective barrier layer and the tungsten layer by chemical
 - 8 mechanical polishing.

- 1 2. The method as set forth in Claim 1 wherein the step of forming a protective barrier layer over
- 2 the tungsten layer further comprises:
- 3 forming a titanium or titanium nitride layer on the tungsten layer.

1 3. The method as set forth in Claim 2 wherein the step of removing at least portions of the
2 protective barrier layer and the tungsten layer by chemical mechanical polishing further comprises:
3 removing portions of the tungsten layer overlying the dielectric layer without removing
4 portions of the tungsten layer within the openings within the dielectric layer.

1 4. The method as set forth in Claim 3 wherein the step of removing at least portions of the
2 protective barrier layer and the tungsten layer by chemical mechanical polishing further comprises:
3 removing all of the protective barrier layer.

1 5. The method as set forth in Claim 3 wherein the step of removing at least portions of the
2 protective barrier layer and the tungsten layer by chemical mechanical polishing further comprises:
3 removing portions of the protective barrier layer overlying dielectric regions between the
4 openings within the dielectric layer.

1 6. The method as set forth in Claim 5 wherein the step of removing at least portions of the
2 protective barrier layer and the tungsten layer by chemical mechanical polishing further comprises:
3 after removing portions of the protective barrier layer overlying the dielectric regions
4 between the openings within the dielectric layer, removing portions of the tungsten layer overlying
5 the dielectric regions between the openings within the dielectric layer; and
6 during removal of portions of the tungsten layer overlying the dielectric regions between the
7 openings within the dielectric layer, removing portions of the protective barrier layer overlying the
8 openings within the dielectric layer.

1 7. The method as set forth in Claim 2 wherein the step of removing at least portions of the
2 protective barrier layer and the tungsten layer by chemical mechanical polishing further comprises:
3 removing portions of the protective barrier layer and the tungsten layer overlying dielectric
4 regions between the openings within the dielectric layer to planarize remaining portions of the
5 tungsten layer and remaining portions of the protective barrier layer, if any, with the dielectric layer.

1 8. A portion of an integrated circuit structure comprising:

2 a dielectric layer over a substrate;

3 a conformal tungsten layer over the dielectric layer and within openings within the dielectric
4 layer; and

5 a protective barrier layer over the tungsten layer and within the openings, wherein the
6 protective barrier layer comprises a material for which removal by chemical mechanical polishing
7 is primarily mechanical.

1 9. The portion of an integrated circuit structure as set forth in Claim 8 wherein the protective
2 barrier layer is titanium or titanium nitride.

1 10. The portion of an integrated circuit structure as set forth in Claim 8 wherein portions of the
2 tungsten layer within the openings are thicker than portions of the tungsten layer over the dielectric
3 layer.

1 11. The portion of an integrated circuit structure as set forth in Claim 8 wherein the protective
2 barrier layer overlies the entire tungsten layer.

1 12. The portion of an integrated circuit structure as set forth in Claim 8 wherein the protective
2 barrier layer overlies portions of the tungsten layer within the openings but not portions of the
3 tungsten layer over the dielectric layer.

1 13. The portion of an integrated circuit structure as set forth in Claim 8 wherein the tungsten
2 layer has a thickness of between about 4500 and 8000 angstroms.

1 14. The portion of an integrated circuit structure as set forth in Claim 8 wherein the protective
2 barrier layer has a thickness of between about 100 and 800 angstroms.

1 15. The portion of an integrated circuit structure as set forth in Claim 8 wherein at least one
2 opening within the dielectric layer is sized to form a capacitive electrode from tungsten within the
3 at least one opening.

1 16. A portion of an integrated circuit structure comprising:
2 a dielectric layer having an opening therein;
3 tungsten within the opening; and
4 a portion of a protective barrier layer over a central region of the tungsten and within the
5 opening, wherein the portion of the protective barrier layer comprises a material for which removal
6 by chemical mechanical polishing is primarily mechanical.

1 17. The portion of an integrated circuit structure as set forth in Claim 16 wherein an upper
2 surface of the tungsten is exposed around the portion of the protective barrier layer.

1 18. The portion of an integrated circuit structure as set forth in Claim 16 wherein the portion of
2 the protective barrier layer is titanium or titanium nitride.

1 19. The portion of an integrated circuit structure as set forth in Claim 16 wherein the tungsten
2 and the portion of the protective barrier layer form an upper surface which is substantially planar
3 with an upper surface of the dielectric layer.

1 20. The portion of an integrated circuit structure as set forth in Claim 16 wherein the opening
2 within the dielectric layer is sized to form a capacitive electrode from the tungsten within the
3 opening.